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EFFICIENCY OF COMMERCIAL EGG CANDLING.

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PURPOSE OF INVESTIGATION.

It is common knowledge among those buying and selling eggs that grading by the candle is not an absolutely dependable method for the separation of good and bad eggs. As it is the best method known for determining the quality of eggs in the shell, however, it is important to learn its degree of efficiency. This bulletin aims to show the effectiveness of commercial candling in detecting different kinds of good and bad eggs, as well as the variations in efficiency of different candling forces. In a previous publication,[1] prepared as a guide to beginners wishing to learn how to candle eggs, detailed descriptions, accompanied in many instances by illustrations, are given of the different types of good and bad eggs of common occurrence. The classifications and descriptive terms given there are used in this publication.

The purpose of the investigation here reported, then, may be summarized as follows: To find (1) the relative error in the candling of different types of good and bad eggs; (2) the relation of the quality of eggs to accuracy in candling; (3) the relative occurrence of bad eggs not to be found by candling; (4) the comparative degree of accuracy of skilled and unskilled candling crews.

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[1] U. S. Dept. Agr. Bul. 565.

PLAN AND SCOPE OF INVESTIGATION.

The investigation was carried on in commercial packing houses located in the Middle West and in distributing houses in the East. During warm weather the eggs under observation were kept in chill-rooms, according to commercial practice, at a temperature of 32° to 40° F., from the time of receipt until the time of candling. This chilling serves to check deterioration and to restore to some extent the natural firmness of the egg substance. For grading, the eggs were removed to candling rooms which were refrigerated to a temperature of 50° to 55° F.

After the eggs had been candled they were opened and graded in accordance with the standards for the preparation of frozen and dried eggs. The number of bad eggs not detected by candling was determined by observing the appearance and odor when opened in glass cups. The conclusions reached in this study were drawn from eggs so handled, which had been graded by commercial candlers according to trade routine. It was the endeavor to grade as edible all eggs with whole yolks which were not seeping, not heavily mottled, nor stuck to the shell, and which contained neither blood nor visible mold infection. Out of the shell an egg was graded as edible if the yolk was whole, the white clear and not colored, and the odor good. If the yolk membrane did not break until the egg was dropped in the grading cup, it was considered edible. The usual speed of candling was not changed, because it was desired to determine the accuracy of the process under commercial conditions.

The eggs rejected by the candlers as unfit for food purposes were critically recandled to find any good eggs that might be present and the reason for their not being found on the first candling. In cases of doubt the eggs were opened. It was not considered necessary or desirable to check the candling of the unquestionably bad eggs by breaking.

The studies reported were made on 187 cases (30 dozen each) of storage-packed eggs, 170.2 cases of refrigerator or cold-storage eggs, 174.4 cases of breaking stock, and 1,521.7 cases of rejected eggs, that is, "rots and spots." The observations on the storage-packed and refrigerator or cold-storage eggs were made from samples having a comparable history. On arrival in the East of carload shipments of commercial storage-packed eggs, from 8 to 20 cases were examined within a comparatively short period after receipt. About the same number from each lot were transferred to a commercial cold-storage warehouse, and withdrawn for candling between the early part of November and the latter part of March. The eggs used for these experiments varied in quality from spring firsts and dirty eggs to summer firsts, seconds, and dirty eggs. These eggs were candled by skilled operators in two large concentrating centers in the East. The storage-packed eggs were, therefore, a very fair representation of the various grades of fresh-gathered market eggs.[1] The accuracy of the candling of the breaking stock was observed in several plants in the Middle West and in two in the East. The candling crews varied widely in efficiency. The rejected eggs studied were from both experienced and inexperienced candlers.

RELATION OF QUALITY OF EGGS TO ACCURACY IN CANDLING.

An analysis of the bad eggs found in eggs candled as edible showed the presence of two distinct groups—one consisting of eggs which are commonly recognized by candling, and the other of types which can be detected only out of the shell. The proportion of the first group in eggs candled as edible may, therefore, be used as an index to the accuracy of candling. The ideal to be attained in candling is the elimination of all errors in the grading of those types of eggs which can be identified before the candle.

The accuracy of skilled candlers depends upon the quality and condition of the stock. Generally speaking, the more bad eggs there are present, the greater will be the number missed. This is not always the case, however, because the type of deterioration influences the accuracy of candling. For example, the black and white rots, moldy eggs, and heavily stuck yolks, characteristic of the bad eggs occurring in dirty eggs, are much more readily detected by candling than the light-blood rings, slightly stuck yolks, and partially disintegrated yolks, common in summer stock (Tables 1 and 11).

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[1] In this publication the terms "fresh-gathered" and "fresh-marketed" eggs refer to eggs which are marketed without the intervention of cold storage.

TABLE 1.—*Effect of quality of eggs upon accuracy of candling.*

Grade.	Number of cases candled.	Bad eggs per case.			
		Total number.	Detected by candling.	Missed by candling.	
				Distinguishable by candling.	Not distinguishable by candling.
FRESH-MARKETED EGGS.					
1914 firsts.					
April	19.56	0.85	0.20	0.20	0.45
May	19.52	2.86	2.39	.21	.26
June	19.23	4.68	4.32	.26	.10
1915 firsts.					
June	8.45	7.10	3.43	2.01	1.66
July	10.45	17.51	13.11	3.06	1.34
1914 dirty eggs.					
April	19.64	5.95	2.65	.91	2.39
May	19.52	12.04	9.02	.92	2.10
June	18.88	19.58	17.62	1.01	.95
July	18.30	25.73	23.11	2.24	.38
1914 seconds.					
July	14.57	7.21	5.91	1.16	.14
1915 seconds.					
June	8.42	20.90	10.81	4.99	5.10
July	10.46	26.72	17.15	4.69	4.88
COLD-STORAGE EGGS.					
1914 firsts.					
April	13.95	9.57	6.59	1.30	1.68
May	14.91	14.15	10.53	2.28	1.34
June	9.75	4.41	3.59	.21	.61
1915 firsts.					
June	14.89	23.89	13.43	7.12	3.34
July	11.67	33.56	19.89	10.11	3.56
1914 dirty eggs.					
April	19.88	16.60	13.28	1.41	1.91
May	25.86	28.38	22.55	2.98	2.85
June	10.07	23.73	20.78	.99	1.96
July	10.22	28.86	27.30	1.56	.00
1914 seconds.					
June	15.03	36.20	19.09	10.77	6.34
1915 seconds.					
June	10.17	14.75	10.61	3.93	.21
July	13.80	32.18	15.65	9.60	6.93

Comparative observations on similar grades of eggs before and after storage showed that the cold-storage or refrigerator eggs were not candled as accurately as the corresponding fresh-gathered eggs (Tables 1 and 11 and fig. 1). As summarized in Table 2, 19.67 per cent of the bad eggs present in the refrigerator eggs were miscandled, as compared with 12.34 per cent in the fresh-gathered eggs. The changes which had taken place in the eggs during holding in cold storage no doubt account for these findings. As an egg ages in cold storage, the opalescent tinge characteristic of the white changes to a cloudy yellow, and the yolk membrane becomes gradually weaker. The contrast between the white and yolk is thereby reduced, and detection of the condition of the egg by candling is rendered more difficult.

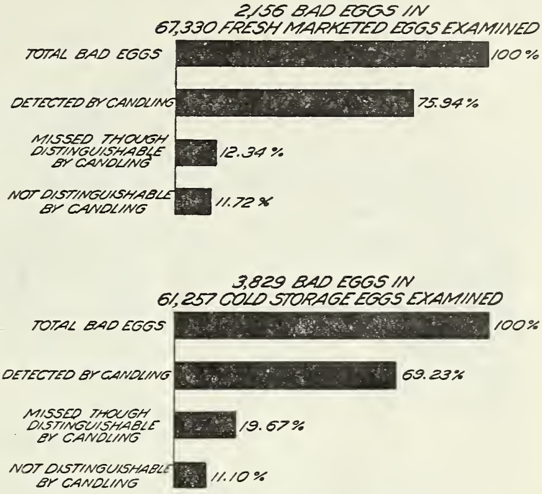

Fig. 1.—Observations on similar grades of eggs candled before and after storage.

It was observed in the different lots of eggs candled that the number of bad eggs not distinguishable by candling varied to practically the same extent as the bad eggs miscandled (Table 1). As mentioned in connection with the miscandled group, the number present depends very largely upon the original quality of the eggs. Green-white and sour eggs, two of the important members of this group, are frequently found among eggs with soiled, wet, or broken shells. These two types of bad eggs are caused by bacteria which enter the eggs through the shells.

Table 2.—*Efficiency of candling in detecting bad eggs.*

Kind.	Number.	Types detected by candling.		Types missed by candling.			
				Distinguishable by candling.		Not distinguishable by candling.	
		Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
Bad eggs from 187 cases (67,330 eggs) commercial storage packed eggs:							
Black rots	340	340	100	0	0	......	......
Heavily stuck yolks	122	122	100	0	0	......	......
Moldy eggs	232	226	97.41	6	2.59	......	......
Large embryos	35	33	94.29	2	5.71	......	......
White rots	505	453	89.71	52	10.29	......	......
Slightly stuck yolks	169	133	78.70	36	21.30	......	......
Blood rings	30	23	76.67	7	23.33	......	......
Mixed rots	450	302	67.12	148	32.88	......	......
Bloody whites	20	5	25	15	75	......	......
Green whites	188	......	......	......	......	188	100
Eggs with bad odor and normal appearance	65	......	......	......	......	65	100
Total	2,156	1,637	......	266	......	253	......
Per cent	......	......	75.94	......	12.34	......	11.72

TABLE 2.—*Efficiency of candling in detecting bad eggs*—Continued.

Kind.	Number.	Types detected by candling.		Types missed by candling.			
				Distinguishable by candling.		Not distinguishable by candling.	
		Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
Bad eggs from 170.2 cases (61,257 eggs) refrigerator or cold storage eggs:							
Black rots	431	431	100	0	0		
Heavily stuck yolks	130	130	100	0	0		
Moldy eggs	810	767	94.69	43	5.31		
White rots	355	328	92.39	27	7.61		
Slightly stuck yolks	525	213	40.57	312	59.43		
Mixed rots	704	453	64.34	251	35.66		
Bloody whites	3	2	66.67	1	33.33		
Crusted yolks	443	324	73.14	119	26.86		
Frozen yolks	3	3	100	0	0		
Green whites	294					294	100
Eggs with bad odor and normal appearance	131					131	100
Total	3,829	2,651		753		425	
Per cent			69.23		19.67		11.10

EFFICIENCY OF CANDLING BAD EGGS IN RECEIPTS.

An analysis was made of the varieties of bad eggs found in the several lots of fresh-gathered and refrigerator eggs given in Table 1. The different kinds of bad eggs detected by candling, the kinds which were miscandled, and those which could be found only when the shell was broken were noted. These observations, covering approximately 357.2 cases candled by experienced candlers in accordance with trade routine, are summarized in Table 2, and given in detail in Table 11. A second series of observations was made on summer breaking stock which included seconds, cracked and dirty eggs, and current receipts. The eggs were candled by the regular candlers, some of whom were experienced and some of whom were not. The types of bad eggs miscandled and the types of bad eggs which could not be found by candling were noted as the eggs were opened in the breaking room (Table 3). At the time that these results were obtained the number of bad eggs, as determined by candling, ranged approximately from 18 to 42 per case. Thirteen types of bad eggs were found, of which all but two could be distinguished by candling, though sometimes they were not.

BAD EGGS DISTINGUISHABLE BY CANDLING.

BLACK ROTS, MOLDY EGGS, AND HEAVILY STUCK YOLKS.

Black rots, eggs having mold spots, and eggs with yolks heavily stuck to the shell are, with few exceptions, readily seen before the candle. Errors in grading these eggs are usually an evidence of carelessness. Mold growths may escape notice if the egg is not completely turned before the candle, or if it is covered with the fingers. If the candler does not concentrate his entire attention upon his work he may make the mistake of putting a black rot or some other bad egg in the case for good eggs, or vice versa. The holding of more than two eggs in each hand increases the likelihood of such mistakes. To reduce the chances for these errors the foreman should instruct the new candlers in the proper manipulation of the eggs, and should not permit talking, except about the work, or any other form of distraction during working hours.

In these studies no errors were noted in the placing of black rots or eggs with heavily stuck yolks in the wrong case. That such an error does sometimes happen is proved by observations in egg-breaking rooms where large numbers of eggs are opened. It happens very infrequently, however, in well-regulated candling rooms where the candlers give their entire attention to their work, and do not talk and joke with their neighbors.

TABLE 3.—*Efficiency of candling in detecting bad eggs in breaking stock.*

62,799 eggs (174.4 cases) candled as good.	96.73 per cent good eggs.		
	3.27 per cent bad eggs.	2.51 per cent types detectable by candling.	1.44 per cent eggs with adherent yolks.
			0.38 per cent blood rings.
			0.40 per cent white rots.
			0.20 per cent mixed rots.
			0.06 per cent moldy eggs.
			0.03 per cent bloody whites, heavily mottled yolks, and eggs with large embryos.
		0.76 per cent types not detectable by candling.	0.52 per cent eggs with bad odors.
			0.24 per cent eggs with green whites.

In Tables 2, 3, and 11 it will be seen that few moldy eggs were misgraded. The six that were miscandled as given in the first part of Table 2 had moldy, free-moving yolks, an unusual form of mold infection. The 43 eggs reported in the last part of Table 2 contained inside the shell small, watery, gelatinous mold spots which were not always distinguishable or seen only indistinctly through the shell before the candle. Those mentioned in Table 3 were cracked eggs with moldy shells and normal contents which are more readily seen by ordinary inspection than by candling. The darkness of the candling room was the probable cause of this mistake. An opening in the lower part of the candle to throw light on the eggs in the cases below helps to reduce such errors.

MIXED AND WHITE ROTS.

Mixed and white rots are common types of bad eggs. Mixed rots, which are an early stage of white rots, are caused by the disintegration of the yolk. In this study of the accuracy of candling extremely weak eggs, eggs with seeping yolks, with or without mottled areas, and eggs with broken yolks will be considered in the mixed rot class, since all represent the first stages of yolk deterioration. The color before the candle of mixed and white rots, like that of fresh eggs, depends on the color of both the shell and the yolk. A light yellow yolk in a white shell has a pale yellow appearance before the candle, and a brown shell or a dark yellow yolk in a white shell gives a reddish color. Brown shells or pale yolks in white shells are factors which reduce the contrast between white and yolk. The candler may very easily confuse the general yellow or pinkish color of good eggs with that of a mixed or white rot if he does not study the condition of the yolk and allow for the color of the shell. Even with close examination it may not be possible always to distinguish between a whole and a broken yolk. In some instances the entire yolk membrane may be so weak that the outline of the yolk changes when the egg is turned, making it difficult to determine whether it is whole or not. In other cases the presence of the yolk in the white, due to seepage, can not be detected because of the opacity of the shell. Again the white may be so firm that it tends to prevent the spreading of the yolk material, even though the yolk sac may be ruptured. These different forms of yolk deterioration are readily recognized when the egg is opened.

Table 2 shows that out of 187 cases of eggs 505 white rots and 450 mixed rots were found, of which 89.71 per cent and 67.12 per cent, respectively, were detected by commercial candling. The proportion of these eggs miscandled in refrigerator eggs was practically the same (Table 2). As white rots are an advanced form of mixed rots, and present more distinctive characteristics before the candle, it is to be expected that the error in candling would be less. The data given in Table 3 further confirm these findings.

EGGS WITH SLIGHTLY STUCK YOLKS.

The egg with the slightly stuck yolk, representing one of the most common types of deterioration in summer, is very frequently miscandled. A pale yolk or a brown shell increases the difficulty of detection. In addition, when the yolk is stuck by a small area only it may sway back and forth so readily that it is difficult to determine whether it is free or adherent. If the turning during the candling tears the yolk from the shell it may be so slightly broken and the white so firm that it is almost impossible to determine whether the yolk is whole or broken. The yellow stain on the shell marking the place where the yolk was stuck and which is characteristic of this egg when out of the shall is not always visible before the candle.

Checking the decision made by candling with the appearance of the egg out of the shell is one of the most effective means of becoming skilled in the grading of eggs with stuck yolks. When they are the prevailing type of bad eggs present judgment of grade should be made as far as possible with the first turning of the egg before the candle, because further rotation often serves to make detection more difficult. The distinguishing feature to be looked for is the adhering portion of the yolk.

In the lots of eggs reported in Table 2 from 40.57 to 78.70 per cent of the eggs with slightly adherent yolks were found by candling. In the summer breaking stock and refrigerator eggs it was the leading type of eggs miscandled (Tables 2 and 3).

BLOOD RINGS AND LARGE EMBRYOS.

Fertile eggs containing blood rings occur most frequently when the weather is sufficiently warm to cause development of the germ spots. In the early stages when there is but a mere trace of blood present, it is not always easy to find them by candling, especially if they happen to be inclosed in a brown shell. In the later stages when the yolk is weak, the blood ring may be covered with a fold in the yolk, and thus escape detection. The blood ring is best seen if the egg is turned gradually before the candle so that the yolk revolves slowly, allowing the germinal spot and the surrounding area which has a rosy appearance to float near the shell. When the yolk is near the shell a darkened area should be looked for, and, if this is present, it should be examined carefully for dark or red streaks or a ring. A candle with a bright light is absolutely necessary if small blood rings are to be found. When the blood-veined area has developed to the size of a 5-cent piece or larger its detection is ordinarily a simple matter.

The ease with which serious errors in failing to find blood-ring eggs may occur was well illustrated in one house under observation where careless candlers working with dimly lighted candles put 3.4 per cent of such eggs into seconds intended to be edible. In the summer breaking stock as many blood rings as white rots were misgraded (Table 3). The use of a candle with a weak light or with an opening which is too large results in failure to detect these eggs.

EGGS WITH BLOODY WHITES.

Eggs with bloody whites are caused by the rupture of the blood vessels during the passage of the egg down the oviduct. Their occurrence is comparatively rare, for out of 357.2 cases of eggs studied but 23 were found. Of these 7 were found by candling and the balance by breaking. These eggs are not readily seen in the shell because the pinkish tint due to the presence of blood is very nearly the same as that given by a brown shell or a white shell containing a dark-yellow yolk. When blood clots are present, as is frequently the case, they serve to make identification easier. If eggs with diffused blood occurred more frequently, candlers would become more familiar with their characteristics, and a larger percentage would no doubt be recognized by candling.

BAD EGGS NOT DISTINGUISHABLE BY CANDLING.

EGGS WITH ABNORMAL ODORS.

Eggs with abnormal odors, including sour and musty eggs, constituted a large proportion of the inedible eggs which could not be detected by candling (Tables 2 and 3). The well-known musty egg in many instances presents an exceptionally fresh appearance before the candle and out of the shell. Only occasionally is the odor so strong that it can be noticed before the egg is opened.

The egg with the sour odor frequently shows such extensive physical deterioration that it can be recognized as a white or mixed rot on candling. If, however, disintegration has not progressed to such an extent, it can not be detected except by the sense of smell when the egg is broken. Bacteriological studies show that the characteristic odor is not produced until the bacteria have developed in large numbers.[1] Eggs having ammoniacal or fishy odors due to bacterial deterioration are not uncommon, and, as in the case of sour eggs, physical changes may not be apparent until an enormous number of bacteria have accumulated. These, too, are identified by the abnormal or characteristic odor apparent when the eggshell is removed.

Because their shells are porous, eggs absorb odors easily from surrounding materials. Very frequently eggs have the odor of moth balls, kerosene, carbolic acid, mold, and damp fillers and flats. Some of the absorbed odors disappear after the egg has been opened, but others remain permanently. Eggs which retain abnormal odors are rejected, and, since the odor is such an important factor in grading eggs out of the shell, great care must be exercised in grading when an odor is present.

EGGS WITH GREEN WHITES.

Eggs with green whites constituted a large proportion of the bad eggs not discernible by candling. They are recognized by the green color of the white when the egg is opened. This color is not present until the specific organisms which produce it have multiplied enormously. Because these eggs are so heavily infected and are chemically decomposed, care should be taken to eliminate them from food products.

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[1] U. S. Dept. Agr. Bul. 51, page 61.

EFFICIENCY OF CANDLING REJECTS.

Just as the bad eggs found in eggs candled as good were studied to determine the reason for their not being discovered, the good eggs found in eggs candled as bad were subjected to critical tests to find out why they were miscandled. In this work attention was directed more to the characteristic appearance before the candle, than to the condition found when breaking the egg out of the shell. The latter method was resorted to only when there was doubt concerning the quality of the egg as ascertained by candling.

To determine how many good eggs were placed with the bad eggs and what the characteristics of these eggs were, 12,024 rejected eggs, mostly from inexperienced candlers, were critically recandled. Among the bad eggs were found 19.9 per cent good eggs, divided between six main groups, namely, brown eggs, hatch-spot and weak eggs, eggs with the yolk floating near the shell, eggs with olive-green yolks, good eggs with broken air cells, and good eggs included because of carelessness (Table 4). As the causes of error for the six types of eggs are different, each will be discussed separately.

Table 4.—*Kinds of good eggs in eggs candled as bad and doubtful (determined by recandling).*

12,024 eggs (33.4 cases) candled as bad and doubtful.	80.1 per cent bad eggs.	
	19.9 per cent good eggs..	6.3 per cent eggs with brown shells.
		5.6 per cent heated eggs, including hatch-spot and weak eggs.
		3.1 per cent eggs with the yolk floating near the shell.
		2.1 per cent eggs with olive-green yolks.
		1.4 per cent good eggs, probably due to carelessness.
		1.2 per cent eggs with movable air cells.
		0.2 per cent eggs with dirty shells, double yolks, and leakers.

GOOD EGGS IN REJECTS.

BROWN EGGS.

Brown eggs constituted about one-third of the good eggs not detected by candling (Table 4). The brown shell, in giving the egg a general reddish color before the candle, reduces the contrast between the white and yolk. This difference is due to a lesser degree of transparency in the case of the eggs with brown shells. The darker the color of the shell, the more difficult it is to judge the condition of the contents. The bad eggs with which good eggs in brown shells may be confused are mainly mixed and white rots, eggs with slightly stuck yolks, blood rings, and eggs with blood in the whites. A candle with a bright light and with an opening of the proper size, so that no rays of light escape around the egg, is a prerequisite for the satisfactory grading of these eggs. With a little study and experience there should be small difficulty in detecting any except those with extremely dark shells. An egg with a stained shell is sometimes miscandled because the appearance before the candle gives a false impression of the condition of the contents. The inspection of the egg without the aid of the candle is usually sufficient to correct this delusion.

HEATED EGGS INCLUDING HATCH-SPOT EGGS AND WEAK EGGS.

Weak eggs and hatch-spot eggs are characteristic of summer seconds. They formed over 5 per cent of the good eggs found in the rejects. The warmth of the summer weather enables the native enzymes to weaken the structure of the egg, and, if the egg happens to be fertile, a partial development of the embryo also occurs. Because the yolk of an egg with a weak vitelline membrane flattens out with each turn before the candle, it is not always easy to determine whether or not the yolk is intact. If the yolk besides being weak shows signs of incubation, it is necessary to determine whether blood is present. A dark shell or a white shell inclosing a light-colored yolk also makes for inaccuracy. If new candlers are not instructed they invariably throw away hatch-spot eggs because of the darkened area on the yolk.

EGGS WITH YOLKS FLOATING NEAR SHELLS.

Eggs with the yolk floating near the shell are frequently mistaken for eggs with slightly adherent yolks, if the candler does not invert each egg to see whether the yolk will move away from the shell. It sometimes happens that the jar of placing an egg with a slightly stuck yolk in the case dislodges the yolk so that upon recandling it has the appearance of a good egg. About 3 per cent of the good eggs found on recandling rejects were eggs with yolks resting near the shell.

TABLE 5.—*Accuracy of recandling rejects.*

House.	Number of eggs broken.	Total bad eggs found.	
		Average per case.	Per cent.
Bad eggs found on breaking good eggs recandled from rejects:			
D	281	33.2	9.24
I (period 1)	1,473	33.7	9.36
I (period 2)	971	77.85	21.63
J	1,152	37.5	10.41
Total	3,877		
Average		45.9	12.75
Good eggs left in rejects after recandling:			
D	720	13	3.5
E	3,600	24.9	6.9
I (period 1)	3,600	2.5	.7
I (period 2)	3,600	2.2	.6
Total	11,520		
Average		11.8	3.3

EGGS WITH OLIVE-COLORED YOLKS.

Eggs with olive-colored yolks, caused probably by the character of the food eaten by the hen, are discarded by inexpert candlers because of the yellowish-green appearance of the yolk before the light. This egg is normal in taste, odor, and appearance except for the greenish tinge in the yolk. It contains no bacteria and shows no chemical deterioration. Such eggs formed 2.1 per cent of the rejects.

EGGS WITH MOVABLE AIR CELLS.

Eggs in which the two shell membranes have been separated or broken so that the air cell changes its location as the egg is turned before the candle are frequently graded as bad because of the difficulty of seeing the condition of the yolk. This difficulty is increased if the yolk is weak or the shell is brown. A quick twirl of the egg before the candle to throw the yolk near the shell aids in identification. Eggs with movable air cells constituted 1.2 per cent of the rejects studied.

ACCURACY IN RECANDLING REJECTS.

In order to test the accuracy of the recandling of the rejects both eggs salvaged as good and eggs rejected as bad were broken and their condition noted.

TABLE 6.—*Kinds of bad eggs found on breaking eggs recandled from rejects as good.*

525 eggs candled from rejects as good.	421 good eggs.		
	104 bad eggs..	33 eggs miscandled........	13 mixed rots.
			11 white rots.
			7 eggs with slightly stuck yolks.
			2 moldy eggs.
		71 eggs not distinguishable by candling.	47 eggs with green whites.
			24 eggs with bad odors.

The percentage of bad eggs found in 3,877 eggs recandled from rejects as good averaged 12.75 per cent, and showed wide variations for the different lots of eggs observed (Tables 5 and 8). These numbers are markedly higher than those found in better grades of eggs after candling (Table 1). This difference is to be expected, because the higher the percentage of bad eggs present, the greater are the chances for errors in candling. Besides this factor, there is the increased difficulty of detecting the good eggs mixed with the rejects as compared with better grades of eggs, because they consist of types of eggs set aside by the original candlers as puzzling or impossible to grade. The types of bad eggs rejected during the breaking of 525 eggs recandled from rejects as good are given in Table 6. In plants having an egg-breaking department the eggs salvaged from rejects are broken, the bad eggs eliminated, and the good eggs used for freezing or drying.

On breaking 32 cases of rejects from which the good eggs had been salvaged by recandling, an average of 11.8 good eggs per case were found, and a variation of 2.2 to 24.9 per case for different houses (Table 5). Is it worth while to break the rejects without recandling in order to save any good eggs which may be among them? This question must be answered in the negative for the following reasons: First, the senses of the breakers become so blunted and bewildered by the bad eggs incurred, that it is impossible, even under competent supervision, to accurately separate the good from the bad eggs. Secondly, the heavy contamination resulting from the preponderance of bad eggs precludes the preparation of a wholesome, clean product. Thirdly, the cost of the time consumed in changing and sterilizing apparatus after bad eggs (which operation can not be omitted) would overbalance the value of the good eggs saved.

ACCURACY OF CANDLING CREWS.

The accuracy of the work of different candling crews is influenced by the following factors:

1. The quality of the eggs to be candled.
2. The skill of the individual candlers.
3. The ability of the foreman to grade eggs and to direct a candling force.
4. The enforcement of a system of checking the work of individual candlers.

The accuracy of the candling of seven different crews was determined from the percentage of bad eggs found on breaking summer seconds candled as good, and from the percentage of good eggs recandled by the foreman or inspector from eggs rejected by individual candlers as bad or difficult to grade.

EXPERIENCED CANDLERS VS. INEXPERIENCED CANDLERS UNDER GOOD MANAGEMENT.

Skilled candling is characteristic of crews in the consuming centers, because work is afforded the whole year and because from them the eggs go to the consumer. When the season of production has passed eggs are withdrawn from storage and candled before being placed on the market. Unskilled candling is typical of the producing districts, as the grading of eggs is carried on only during the commercial laying season, which generally lasts about 5 months. The candlers employed in the spring drift into other occupations in the fall and others take their places the following season. The foremen of candling crews in the producing districts are usually experts who have gained their experience through several seasons of candling, either in the producing districts or in the consuming centers.

TABLE 7.—*Accuracy of candling crews.*

House.	Season of observation.	Location.	Candlers.	Eggs candled as edible.					Eggs candled as bad and doubtful.		
				Number of cases observed.	Bad eggs found on breaking.				Number of cases observed.	Good eggs found by recandling.	
					Miscandled.		Not distinguishable by candling.			Number per case.	Per cent.
					Number per case.	Per cent.	Number per case.	Per cent.			
Skilled crew; good management.											
G	1914	Consuming center	Men	26.95	5.4	1.5	2.9	0.8	....	....	......
I	1914	do	do	....	......	......	......	......	226.25	7.9	2.2
K	1914	Producing section	do	60.55	6.5	1.8	2.9	0.8	27.35	10.8	3.0
Unskilled crew; good management.											
D	1914	Producing section	Men	28.56	2.5	0.7	0.7	0.2	7.15	66.6	18.5
E	1912	do	Women	11.40	10	2.8	8.6	2.4	373	59.4	16.5
F	1912	do	do	5.50	4	1.1	2.2	.6	73.5	39.6	11
Unskilled crew; poor management.											
D	1912	Producing section	Men	7.27	25.9	7.2	4.3	1.2	30	30.2	8.4
J	1914	do	Men and women.	34.19	17.6	4.9	2.2	.6	154.9	132.5	36.8

Where a system of checking the work of unskilled individual candlers was enforced, the number of bad eggs graded by them as good was ordinarily no greater than that found with skilled labor (Table 7 and fig. 2). To accomplish this result with untrained labor the individual candlers were instructed to place all eggs which were difficult to grade with the rejects or in a container by themselves. The rejected eggs from the unskilled crews were recandled by the foreman or another expert, and a record kept of the good eggs thus reclaimed. If an undue number of edible eggs were found, the inspector called the attention of the individual candler to the fact, and gave him the instruction necessary to enable him to avoid future mistakes. The same routine may frequently be followed in the case of skilled labor in order to maintain a high standard of accuracy, and to locate a lack of knowledge on the part of any individual. By this procedure some good eggs were found to be present always in the rejects, especially in those from inexperienced candlers. The reverse should be avoided. From 39.6 to 66.6 eggs per case were salvaged by recandling the rejects from inexperienced candlers thus instructed. If 10 per cent of these eggs were found to be bad on breaking, the number of good eggs saved would still greatly overbalance the cost of recandling. On the other hand, the results of the recandling of the rejects from experienced candlers showed that the value of the good eggs saved did not always pay the cost of the salvaging (Table 8). It will be noted in the table that a larger proportion of the eggs were candled at a profit during the last than during the first period, which fact is accounted for not only by a larger percentage of good eggs, but also by their increased commercial value. In August the wholesale price of eggs was 16 cents, and in November 20 cents per dozen.

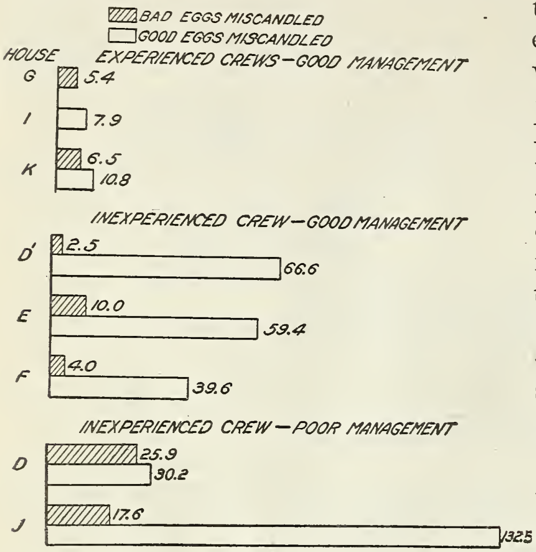

FIG. 2.—Accuracy of candling crews. Data reported as eggs per case.

TABLE 8.—*Comparison of cost of recandling rejects of experienced candlers with value of good eggs salvaged.*

Date, 1915.	Cases rejects re-candled.	Good eggs found on recandling.	Bad eggs discarded on breaking.	Good eggs salvaged.		Labor of man recandling.	
		Dozen.	*Dozen.*	*Dozen.*	*Value.*	*Hours.*	*Cost.*
Period 1:							
July 31	20	$13\frac{5}{12}$	$1\frac{2}{3}$	$11\frac{3}{4}$	$1.88	$5\frac{1}{2}$	$1.65
August 3	20	$6\frac{1}{3}$	$\frac{2}{3}$	$5\frac{2}{3}$	.91	4	1.20
August 7	20	$9\frac{2}{3}$	$2\frac{1}{2}$	$7\frac{1}{6}$	1.15	$5\frac{1}{2}$	1.65
August 11	31	14	1	13	2.08	8	2.40
August 16	37	23	1	22	3.52	10	3.00
August 18	$19\frac{1}{2}$	8	$\frac{1}{3}$	$7\frac{2}{3}$	1.23	6	1.80
Do	15.4	14	$1\frac{1}{3}$	$12\frac{2}{3}$	2.03	5	1.50
Total	162.9	$88\frac{5}{12}$	$8\frac{1}{2}$	$79\frac{11}{12}$	12.80	44	13.20
Average per case	....	6.5 eggs.	0.5 eggs.	6 eggs.	0.08	16 min.	0.08
Period 2:							
November 4	$8\frac{1}{2}$	$19\frac{1}{3}$	3	$16\frac{1}{3}$	3.27	3	.90
November 5	$3\frac{1}{2}$	$8\frac{2}{3}$	$\frac{11}{12}$	$7\frac{3}{4}$	1.55	$1\frac{1}{2}$	.45
November 6	$4\frac{1}{4}$	$5\frac{1}{2}$	$\frac{5}{6}$	$4\frac{2}{3}$	.93	$1\frac{1}{2}$	.45
November 9	9	14	$2\frac{7}{12}$	$11\frac{5}{12}$	2.28	2	.60
November 10	6	7	3	4	.80	$2\frac{1}{4}$	.68
November 11	8	$10\frac{5}{6}$	3	$7\frac{5}{6}$	1.57	$3\frac{1}{2}$	1.05
November 16	$6\frac{1}{2}$	$5\frac{5}{6}$	$\frac{5}{6}$	5	1.00	$1\frac{1}{4}$	.38
November 17	$5\frac{1}{2}$	$6\frac{1}{6}$	$\frac{3}{4}$	$5\frac{5}{12}$	1.08	$1\frac{1}{2}$	.45
November 18	6	$3\frac{1}{2}$	$1\frac{1}{2}$	2	.40	$1\frac{1}{2}$	.45
November 19	3	2	$1\frac{1}{12}$	$\frac{11}{12}$	.18	$\frac{1}{2}$	.15
Total	$60\frac{1}{4}$	$82\frac{10}{12}$	$17\frac{1}{2}$	$65\frac{1}{3}$	13.06	$18\frac{1}{2}$	5.56
Average per case	....	16.5 eggs.	3.5 eggs.	13 eggs.	.22	18.42 min.	.09

TABLE 9.—*Accuracy of individual inexperienced candlers at E House, determined by recandling breaking stock and rejects.*

Candler No.	Number of cases of rejects candled.	Number of cases of good eggs recandled.	Good eggs in rejects.	Bad eggs in good eggs.
			Per cent.	*Per cent.*
1	16	20.4	8.7	0.5
2	8	16.4	9.3	.4
3	29	24.0	11.1	.7
4	19	22.8	11.8	.7
5	15	20.8	13.9	.5
6	28	22.4	15.1	1.2
7	18	22.0	15.4	.9
8	26	16.4	16.6	.8
9	5	5.8	16.7	.2
10	40	22.8	17.3	.6
11	38	21.6	17.7	.9
12	19	12.4	18.0	.7
13	37	22.8	18.9	.3
14	30	10.8	19.4	.8
15	15	10.8	21.3	.7
16	30	16.8	34.0	1.0
Total	373	289		
Average			16.5	.7

Even though the rejects from experienced candlers may sometimes be recandled at a loss, it is worth while occasionally to discipline the candlers to accurate work. For example, on November 4 an average of 3 dozen good eggs per case was found by recandling the rejects of an experienced force. After the results were made known to the crew the number of good eggs miscandled was markedly reduced (Table 8). Variations in the accuracy of inexperienced candlers working under the direction of a skilled foreman are given in Tables 9 and 10.

INEXPERIENCED CREWS UNDER POOR MANAGEMENT.

The results given in Table 7 and figure 2 show what may be expected when inexperienced workers are allowed to grade eggs without intelligent supervision.

The candling crew of D House in 1912 was governed by an incomplete system of inspection. The rejects were recandled by the foreman to save the good eggs, but the pails of goods eggs going to the breaking room were not identified, so that errors in candling could be traced to the original candlers. The candlers, knowing that their rejects only were being examined, became so cautious about discarding good eggs that they erred in the other direction, and put an undue number of bad eggs into the pails of eggs for the breaking room. As no discipline was enforced the employees continually talked with each other instead of concentrating their attention upon their work.

A combination of factors led to inaccurate work in J House. No foreman was in direct charge of the work; the candlers were inexperienced; the eggs were of low quality; and practically no system of checking the work of individual candlers was in operation. The one expert in the force was delegated to recandle the rejects, to reclaim any good eggs which might be present. He did not instruct the candlers regarding their mistakes in grading. Consequently their work did not improve with added experience.

ESSENTIALS OF GOOD MANAGEMENT.

From the foregoing it may be concluded that for the preparation of standard grades of food eggs a rigid system of inspection of the work of individual candlers must be enforced, particularly when a force of inexperienced candlers is employed. This system should include not only the recandling of the rejects, but also daily representative portions of the eggs graded as good. If the plant is equipped with an egg-breaking room, the accuracy of the candling of the breaking stock can be easily checked as the eggs are opened. To carry out such an inspection system each candler should be instructed to place a tag bearing his initials or his number in each case or pail of eggs candled by him, so that when mistakes are found they can be traced and corrected. Each candler should direct his entire attention to his work and such distractions as conversation should not be permitted. A foreman versed in the handling of eggs and having executive ability is a prerequisite.

Table 10.—*Accuracy of individual inexperienced candlers at D house as determined by recandling rejects by candling-room foreman.*

Candler No.	Number of eggs examined.	Bad eggs.	Good eggs.	Kinds of good eggs.						
				Thick shells.	Heated.	Watery.	Good (carelessness).	Settled yolk.	Olive-green yolk.	Miscellaneous.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	144	94.4	5.6	4.2	....	....	....	0.7	....	0.7
2	111	92.0	8.0	3.9	0.6	0.6	1.7	.6	0.6	....
3	132	87.0	13.0	7.40	1.9	.9	....	1.9	.9	....
4	108	82.1	17.9	15.5	1.2	....	....	1.2	....	....
5	84	80.9	18.9	6.3	5.4	....	2.7	4.5	....	....
6	180	78.0	22.0	15.2	1.5	.8	1.5	1.5	1.5	....

SUMMARY.

In bad eggs graded commercially by the candle as fit for food purposes there was found one group composed of eggs which could have been detected before the candle and another for which the present system is inadequate. The proportion of the first group in edible grades can, therefore, be taken as one measure of the efficiency of grading eggs by the candle.

The accuracy of candling depends upon the quality of the eggs and the skill of the candlers. With experienced workers the number of bad eggs found in high-grade eggs after candling is negligible. On the other hand, when a large percentage of the good eggs in the supply have weak whites and yolks and the percentage of bad eggs runs high, the difficulty of distinguishing between edible and inedible eggs is increased, and the number of bad eggs miscandled is greater. In the studies with skilled candlers the average number of bad eggs miscandled in a case of 30 dozen varied from 0.20 in spring firsts to 10.77 in very low-grade refrigerator or cold-storage eggs. The number of bad eggs which could not be found by candling ranged from none to 6.93 per case, depending upon the grade of eggs examined. The data, as summarized from another point of view, show that out of 5,985 bad eggs present in 128,587 eggs, 71.65 per cent were detected by candling, 17.02 per cent were missed by candling, and 11.33 per cent were not distinguishable by candling.

Black rots, eggs with moldy spots, and eggs with heavily adherent yolks present such distinctive characteristics before the candle that their presence in edible grades is an evidence of carelessness. White rots, but more particularly mixed rots, eggs with yolks slightly stuck to the shell, blood rings, and eggs with bloody whites do not always show such striking features before the candle. These are the eggs which are found chiefly in the miscandled group of bad eggs. A brown shell or a light colored yolk is a factor which reduces the contrast between white and yolk, making differentiation between good and bad eggs more difficult.

Eggs with green whites and eggs with normal appearance but having bad odors constituted the group not recognizable by candling.

The good eggs which were frequently miscandled, especially by inexperienced candlers, were those with brown shells, hatch-spot eggs, weak eggs, eggs with the yolk floating near the shell, eggs with olive-colored yolks, and eggs with movable air cells. The average number of bad eggs found in the rejects by recandling was a dozen to the case, or less, with experienced candlers, and from 3 to 6 dozen with inexperienced candlers under good management. In the latter instance the candlers were directed to put all doubtful eggs with the rejects, which were then recandled by an expert. In plants having poor management and poor candlers the number of good eggs in the discards sometimes reached 11 dozen to the case.

The enforcement of a system of checking the work of individual candlers, particularly in plants employing inexperienced help, was found to be the best way to maintain high efficiency in a candling force.

TABLE 11.—*Data in detail, showing accuracy of candling.*

FRESH-MARKETED EGGS.

Grade.	Total number eggs examined.	Total bad eggs found.	Types of bad eggs detected by candling.												Types of bad eggs missed by candling.											
															Distinguishable by candling.									Not distinguishable by candling.		
			Total.	Black rots.	Heavily stuck yolks.	Moldy.	Large embryos.	White rots.	Slightly stuck yolks.	Blood rings.	Frozen yolks.	Mixed rots.	Bloody whites.	Crusted yolks.	Total.	Large embryos.	White rots.	Slightly stuck yolks.	Moldy.	Mixed rots.	Blood rings.	Bloody whites.	Crusted yolks.	Total.	Green whites.	Bad odors and normal appearance.
1914 firsts.																										
April	7,042	17	4	.....	.....	.....	.....	2	1	.....	.....	1	.....	.....	4	.....	.....	1	.....	.....	.....	3	.....	9	6	3
May	7,029	55	46	17	5	4	.....	2	2	2	.....	14	.....	.....	4	.....	1	2	.....	1	.....	.....	.....	5	4	1
June	6,923	90	83	11	8	11	3	28	9	.....	.....	13	.....	.....	5	.....	2	1	.....	.....	.....	2	.....	2	2	.....
1915 firsts.																										
June	3,042	60	29	.....	.....	2	.....	11	2	.....	.....	14	.....	.....	17	.....	.....	1	.....	15	.....	1	.....	14	13	1
July	3,762	183	137	18	.....	30	8	25	16	.....	.....	40	.....	.....	32	.....	7	2	.....	23	.....	.....	.....	14	12	2
1914 dirty eggs.																										
April	7,072	117	52	17	14	4	.....	12	.....	.....	.....	5	.....	.....	18	.....	2	3	.....	11	.....	2	.....	47	25	22
May	7,029	234	175	79	21	7	.....	52	6	.....	.....	6	4	.....	18	.....	7	.....	.....	7	.....	4	.....	41	22	19
June	6,800	370	333	108	24	27	5	111	9	1	.....	48	.....	.....	19	.....	6	7	.....	4	.....	2	.....	18	15	3
July	6,589	471	423	65	39	54	1	120	49	16	.....	79	.....	.....	41	2	12	4	.....	16	7	.....	.....	7	5	2
1914 seconds.																										
July	5,245	104	85	4	11	3	.....	34	10	4	.....	19	.....	.....	17	.....	5	8	.....	4	.....	.....	.....	2	2	.....
1915 seconds.																										
June	3,031	176	91	5	.....	23	.....	23	17	.....	.....	23	.....	.....	42	.....	7	4	.....	31	.....	.....	.....	43	35	8
July	3,766	279	179	16	.....	61	16	33	12	.....	.....	40	1	.....	49	.....	3	3	6	36	.....	1	.....	51	47	4
Total	67,330	2,156	1,637	340	122	226	33	453	133	23	.....	302	5	.....	266	2	52	36	6	148	7	15	.....	253	188	65

COLD-STORAGE EGGS.

1914 firsts.																										
April	5,023	131	90	13	2	35	....	9	2	....	....	9	....	20	18	....	....	5	....	7	....	....	6	23	12	11
May	5,366	211	157	29	16	66	....	13	2	....	....	15	....	16	34	....	3	8	....	11	....	....	12	20	16	4
June	3,508	42	35	4	1	3	....	8	4	....	1	13	....	1	2	....	1	....	....	....	....	....	1	5	2	3
1915 firsts.																										
June	5,362	355	200	8	....	75	....	23	25	....	....	47	....	22	106	....	2	36	21	39	....	....	8	49	34	15
July	4,198	392	232	22	....	46	....	37	23	....	....	82	....	22	118	....	....	48	3	53	....	1	13	42	33	9
1914 dirty eggs.																										
April	7,158	330	264	34	38	102	....	24	12	....	2	7	2	43	28	....	7	2	....	5	....	....	14	38	29	9
May	9,311	734	583	182	35	142	....	57	29	....	....	37	....	101	77	....	2	12	2	27	....	....	34	74	43	31
June	3,626	229	210	69	7	56	....	36	12	....	....	6	....	24	10	....	....	....	1	....	....	....	9	9	8	1
July	3,678	295	279	33	27	62	....	44	42	....	....	57	....	14	16	....	....	1	2	7	....	....	6	0	....	....
1914 seconds.																										
July	3,662	149	108	3	....	11	....	24	24	....	....	45	....	1	39	....	7	11	....	19	....	....	2	2	1	1
1915 seconds.																										
June	5,401	534	277	22	4	72	....	53	18	....	....	73	....	35	162	....	4	98	8	48	....	....	4	95	59	36
July	4,964	427	216	12	....	97	....	....	20	....	....	62	....	25	143	....	1	91	6	35	....	....	10	68	57	11
Total	61,257	3,829	2,651	431	130	767	....	328	213	....	3	453	2	324	753	....	27	312	43	251	....	1	119	425	294	131

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